SYSTEM ESTIMATES OF CYCLICAL UNEMPLOYMENT AND CYCLICAL OUTPUT IN THE 15 EUROPEAN UNION MEMBER-STATES

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Abstract:
The purpose of this paper was to estimate cyclical unemployment and cyclical output in the 15 European Union member-states using a system of Phillips curve and Okun's law equations. Treating both the NAIRU and the potential output growth rate as time varying unobserved stochastic processes, a state-space maximum likelihood estimation method - using Kalman filter where the state variables were random walks - was followed in order to estimate the 15 systems of equations. Overall, the estimated with the new approach systems of conditional equations suggested that the extent and direction of changes of cyclical unemployment and cyclical output over the period 1961-1999 is mixed across the 15 EU member states. The paper concludes that the application of "common" policies across the 15 EU member states may be questionable because of the different expected effects of these policies on the various economies.

Key words: Phillips curve, Okun's law, Kalman filter, Cyclical unemployment, Potential output growth rate, NAIRU, Europe.
JEL classification: C32, E32

1.Introduction

Although the original Phillips (1958) curve relates inversely wage inflation to the unemployment rate, the term 'Phillips curve' gradually came to describe the relation between the rate of inflation of prices and the unemployment rate. This relation may be written as

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$$\pi_t = \beta(U_t - U_{NR}) + \varepsilon_t \qquad (1)$$

where: $\pi_t = (P_t - P_{t-1})/P_{t-1}$ = price inflation rate in period t, P_t = price level in period t, U_t = total unemployment rate in period t, U_{NR} = natural rate of unemployment (later called the 'Non-Accelerating Inflation Rate of Unemployment' (NAIRU). The U_{NR} and U_{NAIRU} are alternative ways of defining the goal of full employment when it is to be pursued with fiscal and monetary policies, and thus, they are alternatively called as the 'full employment rate' (U_F)).β = parameter that measures the responsiveness prices to unemployment, where β <0, ε_t = disturbance term in period t.

However, taking into account that total unemployment is the sum of cyclical, frictional and structural unemployment, and that frictional and structural unemployment are the two components of natural unemployment, then, the term (U_t-U_{NR}) in equation (1) measures the cyclical unemployment rate, which highly responds to fiscal and monetary policies; the natural rate of unemployment depends more on other inherent features within the economy, such as misinformation and mismatches within the labour markets. Therefore, equation (1) advocates that fluctuations in cyclical unemployment inversely affect price inflation, and the NAIRU is consistent with a constant rate of price inflation.

Inversely to the fluctuations of cyclical unemployment, or deviations of total unemployment from the NAIRU, is the pace of economic expansion, which highly depends on fiscal and economic policies. This relationship between cyclical unemployment and economic expansion, expressed by fluctuations in Gross Domestic Product, is written by Okun (1962) as the 'Okun's Law' equation

$$g_t = \delta(U_t - U_{NR}) + \eta_t \qquad (2)$$

where: $g_t = (GDP_t - GDP_{t-1})/GDP_{t-1}$ = growth rate of real output in period t, GDP_t = real Gross Domestic Product in period t, δ = parameter that measures the responsiveness output to unemployment, where δ <0, η_t = disturbance term in period t.

After the collapse of the trade-off between inflation and unemployment (output) that the Phillips curve were offering, equations (1) and (2) were extended, in order to include supply-side and expectational factors (Phelps, 1967; Friedman, 1968), into the following equations:

$$\pi_t = \pi_t^e + \beta(U_t - U_{NAIRU}) + \gamma(U_t - U_{t-1}) + \varepsilon_t \qquad (3)$$

$$g_t = g_t^p + \delta(U_t - U_{NAIRU}) + \eta_t \qquad (4)$$

where: π_t^e = expected price inflation rate in period t, g_t^p = potential growth rate of real output in period t, γ = parameter that measures the extent to which changing unemployment (U_t-U_{t-1}) affects inflation, where γ <0.

Recently, and due to the introduction of new methods of estimation in econometrics, the estimation of the NAIRU and of the potential output - using the Phillips and Okun equations - have drawn attention as important topics of research in economics (Apel and Jansson, 1999; Fair, 2000; Richardson *et al.,* 2000; Laubach, 2001). General specification forms of these two equations may be the following:

$$\pi_t = \pi_t^e + \beta(L)(U_t - U_t^{NAIRU}) + \gamma(L)S_t + \varepsilon_t \qquad (5)$$

$$\text{with } \pi_t^e = \alpha(L)\pi_{t-1} \qquad (6)$$

$$g_t = g_t^p + \delta(L)(U_t - U_t^{NAIRU}) + \eta_t \qquad (7)$$

$$\text{with } g_t^p = \theta(L)g_{t-1} + \zeta(L)T_t \qquad (8)$$

where: $\alpha(L)$, $\beta(L)$, $\gamma(L)$, $\delta(L)$, $\theta(L)$, $\zeta(L)$ = polynomials in the lag operator, S_t and T_t = supply or production determination variables for the Phillips and Okun equations respectively, U_t^{NAIRU} = time varying NAIRU.

In estimating equations (5) and (7) the following methodological options may be considered:

1. Equations (5) and/or (7) may be estimated individually (Kutner, 1994; Jaeger and Parkinson, 1994; Fair, 2000; Richardson *et al.*, 2000; Laubach, 2001) or as a system of equations (Apel and Jansson, 1999).
2. The time varying NAIRU may alternatively modelled as a deterministic function of time (Staiger *et al*, 1997a, 1997b), as an unobserved stochastic process (Gordon, 1997; Staiger *et al*, 1997b; Laubach, 2001), or as a function of structural economic variables (Weiner, 1993; Staiger *et al*, 1997b).
3. The time varying potential output may alternatively modelled as a deterministic function of time, or as an unobserved stochastic process (Kutner, 1994; Jaeger and Parkinson, 1994; Apel and Jansson, 1999).

From the available options the time varying NAIRU and potential output unobserved stochastic processes modelling incorporates economic content that it is absent from the deterministic function modelling. Furthermore, any attempt to measure the NAIRU estimating individually either the Phillips equation or the Okun equation will most probably result in different estimates. Finally, a system of equations which explicitly incorporates the co-variation restriction on cyclical output, cyclical unemployment and price inflation suggested by theory, is a satisfactory model for describing the mutual dependency of output, unemployment and inflation (Apel and Jansson, 1999). Summarising the relevant literature, we may say that the main problem in the research referring to the estimation of the relationship between inflation, output and unemployment, using a Phillips curve or an Okun's law specification, is the uncertainty surrounding the estimates of the NAIRU and the potential output growth rates, and therefore, it is important any contribution to this area to be concentrated on new specifications of the equations involved and on new estimating techniques that will add to our knowledge.

Considering the last paragraph, the purpose of this paper is to estimate cyclical unemployment and cyclical output for each one of the 15 European Union (EU) member-states, using a system of Phillips and Okun equations. For this purpose the NAIRU and potential output to be estimated follow the unobserved stochastic process modelling and are estimated conditionally with respect to the two equations of the system. Section 2, presents the specific model to be estimated and employing the Augmented Dickey-Fuller (ADF) tests, investigates the non-stationarity of all the data used. The statistical estimates of the model, using the Kalman filter estimation methodology, and discussion of the meaning of these estimates is presented in section 3. Section 4 presents the time varying estimates of the NAIRU and the potential output for the 15 European Union member-states. Finally, section 5 presents the conclusions and policy implications of the paper. All estimates have been carried out using EViews 3.1.

2. The model and the data involved

The first equation of the system of the two equations employed in this paper includes a modified version of the Gordon's(1982, 1985, 1997) type Phillips curve

$$\begin{aligned} &\pi_t = \alpha\pi_{t-1} + \beta_0(U_t - U_t^{NAIRU}) + \gamma pm_t + \varepsilon_t \\ &0 < \alpha \leq 1 \ , \ \ \beta_0 < 0 \ , \ \ g \geq 0 \end{aligned} \tag{9}$$

where $U_t^{NAIRU} = \beta_t U_{t-1} + \varepsilon_{1,t}$ (10)

β_t is a time varying parameter to be estimated, pm_t is import prices inflation in period t, and $\varepsilon_{1,t}$ is a disturbance term. Equations (9)-(10) relate prices inflation to cyclical unemployment (i.e. the difference between the level of unemployment and the NAIRU) which proxies demand pressures; the lag in the prices inflation term captures any inertia (in the case where the restriction of α being equal to one is imposed, then, this term can be thought as picking up expectational effects); the import prices inflation refers to supply pressures, incorporating thus imported inflation. Equation (9) specifies a meaningful NAIRU in the case where inflation is integrated of order one, i.e. is π~I(1), α=1 and γ=ε=0. In this case then, when U_t=U_t^{NAIRU}, it is π_t=π_{t-1}, meaning that equation (9) addresses the problem of estimating the relationship between price inflation and cyclical unemployment conditional on import prices supply shocks (Apel and Jansson, 1999). The second equation is

$$g_t = g_t^p + \delta(U_t - U_t^{NAIRU}) + \eta_t \qquad (11)$$
$$\delta < 0$$

where
$$g_t^p = \theta_t g_{t-1} + \zeta q_t + \eta_{1t} \qquad (12)$$
$$\zeta \geq 0$$

θ_t is a time parameter to be estimated, q_t is labour productivity in time period t and $\eta_{1,t}$ is a disturbance term. Equations (11)-(12) relate cyclical unemployment to cyclical growth rates of real output and allow the estimation of the NAIRU and the potential growth rate. In fact, the potential growth rate incorporates two components: an unobserved component ($\theta_t g_{t-1}$) which refers to the overall pace economic expansion, and a structural component (ζq_t) which refers to the production technological conditions captured by labour productivity. Finally, assuming that variables β_t and θ_t are characterized by stochastic trends, this means that U_t^{NAIRU} and g_t^p are also characterized by stochastic trends, implying that $U_t \sim I(1)$, $g_t \sim I(1)$ and $q_t \sim I(1)$. The advantage of equations (10) and (12) is that they combine both unobservable variables (β_t and θ_t) and economically meaningful observed information (U_{t-1}, g_{t-1} and q_{t-1}).The data used in the analysis is annual, cover the period from 1961 to 1999 and are taken from European Economy (1999).

The identification of the variables used is the following: p=prices inflation (price deflator private consumption; annual percentage change from national currency). U = unemployment rate (total; percentage of civilian labour force). q =labour productivity growth (gross domestic product at 1990 market prices per person employed; annual percentage change from national currency). g =output growth rate (gross domestic product at 1990 market prices; national currency; annual percentage change). pm =import prices inflation (price deflator imports of goods and services; annual percentage change from national currency).

In examining the stationarity of these variables we used the Dickey-Fuller (DF) and Augmented Dickey-Fuller (ADF) tests as shown in Table 1 (Dickey and Fuller, 1979 and 1981; Dickey and Pantula, 1987; Dickey *et al,* 1984). The exact methodology followed is as follows (Seddighi *et al*, 2000): In order to find the proper structure of the DF/ADF equations, in terms of the inclusion in the equations of an intercept (c) and a trend (t), and in terms of how many extra augmented lagged terms to include in the ADF equations, for eliminating possible autocorrelation in the disturbances, the usual Akaikes's (1973) information criterion (AIC) and Schwartz's (1978) criterion (SC) were employed. The minimum values of AIC and SC indicated the 'best' structure of the ADF equations. With respect to testing autocorrelation in the disturbances, the usual Breusch (1978) and Godfrey (1978) or Lagrange multiplier LM(1), test was used.

The structure of the figures presented in Table 1 is as follows: For each country and for each variable (in each cell) there are two figures of the DF/ADF statistics. The top figure refers to the actual (level) variable and the bottom figure refers to the 1st differenced variable. Next to each figure there are three indicators; the first shows the corresponding numbers of the lagged terms used to eliminate possible autocorrelations in the disturbances, the second shows the inclusion in the equations of an intercept (c) and the third shows the inclusion of a trend (t). Comparing the DF/ADF statistics in Table 1, with the MacKinnon (1991) critical values, shown at the bottom of Table 1, the following conclusions may be derived: 1)The statistics referring to the actual levels show that the vast majority of the variables are non-stationary. However, these statistics show that the corresponding 1st differenced variables are stationary. In other words the vast majority of the variables in Table 1 are integrated of order one, i.e. they are I(1). 2)Variables marked with asterisks (one asterisk for the case of including intercept only; two asterisks for the case of including intercept and time trend) are at the 5% significant level neighbourhood of being I(1). 3)Variables q_i (for i=7, 9, 10, 12, 15), g_i (for i = 9, 12, 15) and pm_i (for i=3) are stationary. 4)Because only 9 variables are stationary, from a total of 80 variables, for comparison purposes, in the estimation bellow we will treat all variables as being I(1).

Table 1. DF/ADF unit root tests for all the variables

Country	p		U		q		g		pm	
1. B	-2.73 -4.50	1,c,t 1,c	-2.26 -3.58	1,c,t 1,c,t	-1.76 -8.94	2,c 2,c	-3.29 -6.45	1,c,t 1,c	-2.71 -5.68	2,c 1,c
2. DK	-1.84 -5.160	1,c,t 1,c	-1.69 -4.12	1,c 0,c	-2.51 -5.46	2,c,t 2,c	-2.75 -5.67	2,c,t 1,c	-3.23 -6.67	1,c,t 1,c
3. D	-3.10 -3.91	1,c,t 1,c	-3.11 -4.31	2,c,t 1,c	-2.92 -6.32	2,c,t 2,c	-3.40 -7.22	2,c,t 1,c	-3.70 -6.01	1,c,t^{s} 1,c
4. EL	-1.74 -4.95	1,c 1,c	-2.25 -3.52	2,c,t 2,c	-2.02 -7.04	2,c,t 1,c	-2.28 -7.58	2,c,t 1,c	-2.38 -4.64	1,c,t 1,c
5. E	-1.45 -4.60	1,c,t 1,c	-1.87 -3.11	2,c,t 1,c	-2.41 -6.14	2,c 2,c	-2.74 -6.06	1,c 1,c	-2.91 -7.66	1,c 1,c
6. F	-1.26 -5.63	1,c 0,c	-2.23 -3.29	1,c,t 1,c	-3.19 -6.84	1,c,t 1,c	-3.10 -6.20	1,c,t 1,c	-3.20 -7.16	1,c,t 1,c
7. IR	-1.78 -5.06	1,c 0,c	-1.58 -3.30	1,c 1,c,t**	-3.11 -8.20	2,c^{s} 1,c	-2.91 -7.11	1,c,t 1,c	-2.70 -5.96	1,c,t 1,c
8. I	-1.51 -5.13	1,c 0,c	-2.42 -5.93	2,c,t 1,c	-3.39 -6.52	1,c,t** 1,c	-3.92 -7.17	2,c,t^{s} 1,c	-2.61 -5.99	1,c 1,c
9. L	-2.65 -4.09	1,c 1,c	-2.29 -3.71	1,c,t 1,c	-5.64 -6.76	1,c^{s} 1,c	-3.41 -6.63	2,c^{s} 2,c	-3.56 -6.40	1,c,t** 1,c
10. NL	-2.37 -3.86	1,c,t 1,c	-1.63 -3.81	2,c 1,c	-3.81 -5.82	2,c,t^{s} 2,c	-3.25 -6.44	1,c,t 1,c	-2.92 -6.56	2,c,t 1,c
11. A	-1.66 -6.80	1,c 0,c	-2.75 -4.98	1,c,t 1,c	-2.05 -9.59	2,c,t 1,c	-2.27 -8.64	2,c,t 1,c,t	-2.62 -7.93	2,c,t 1,c
12. P	-1.37 -6.93	1,c 0,c	-2.26 -3.49	1,c,t 0,c	-5.94 -7.80	1,c,t^{s} 1,c	-2.85 -4.43	2,c,t 1,c,t	-2.35 -7.28	1,c 1,c
13. FI1	-2.59 -5.28	1,c,t 1,c	-2.54 -4.60	2,c,t 1,c	-3.31 -7.33	2,c,t** 1,c	-2.97 -6.10	2,c* 1,c	-2.92 -6.68	1,c 1,c
14. S	-1.38 -5.26	1,c,t 1,c,t	-1.84 -4.03	2,c,t 1,c	-2.43 -7.95	2,c 1,c	-3.08 -7.04	2,c,t 1,c	-2.99 -6.59	1,c* 1,c
15. UK	-2.04 -4.90	1,c 1,c	-1.18 -4.47	2,c,t 1,c	-6.16 -7.40	1,c,t^{s} 1,c	-4.83 -6.64	1,c^{s} 1,c	-2.90 -5.98	1,c,t 1,c
16. EU	-1.47 -4.10	1,c 1,c	-2.68 -3.64	1,c,t 1,c	-3.79 -8.04	1,c,t^{s} 1,c	-2.57 -7.45	2,c,t 1,c	-2.84 -6.28	1,c 1,c

* Critical values (including intercept): -3.62 (1%); -2.94 (5%); -2.60 (10%).** Critical values (including intercept and time trend): -4.22 (1%); -3.53 (5%); -3.20 (10%).^{s} Stationary. Variables in levels and first differences.

3. The model estimates

In order to estimate cyclical unemployment, i.e. estimating first the time varying NAIRU, and cyclical output growth rate, i.e. estimating first the time varying potential output growth rate, the estimation issues followed may be summarised as follows: All the variables involved in the estimation assumed to be I(1). In this case estimates will not produce spurious results (Gujarati, 1995; Seddighi *et al.*, 2000). The specification of the model described in the system of equations (9)-(12) can be written in a state-space form as follows:

Measurement equations:

$$p_t = \alpha p_{t-1} + \beta_0 (U_t - \beta_t U_{t-1}) + \gamma pm_t + \varepsilon_t \qquad (13)$$

$$g_t = \theta_t g_{t-1} + \delta (U_t - \beta_t U_{t-1}) + \zeta q_t + \eta_t \qquad (14)$$

Transition equations:

$$\beta_t = \phi_1 \beta_{t-1} + u_t \qquad (15)$$

$$\theta_t = \phi_2 \theta_{t-1} + v_t \qquad (16)$$

where β_t and θ_t are the state variables, φ_1 and φ_2 are parameters and the disturbance terms ε_t, η_t, u_t and v_t are assumed to be independent and white noise.

The parameters of the equations (13)-(16) can be estimated by maximum likelihood using the Kalman filter. The Kalman filter is a recursive algorithm for sequentially updating the state variables given past information. More technically, it is an algorithm for calculating linear least squares forecasts of the state variables given data observed up to date t (Cuthbertson *et al.*, 1992; EViews, 1998).The state variables are either random walk (assuming $\varphi_1 = 1$ and $\varphi_2 = 1$; shocks to the random coefficient persist indefinitely) or AR(1) and constant mean (assuming $\varphi_1 \neq 1$ and $\varphi_2 \neq 1$; shocks to the random coefficient have some persistence, but that the coefficient eventually returns to its mean value). Because the data is annual, at most two lags in the independent variables of equations (13)-(14) are used.

Tables 2 and 3 present the estimated Phillips and Okun equations respectively using Kalman filter. The estimates refer to the state variables following a random walk process. Experiments assuming that the state variables follow an AR(1) and constant mean process were also performed but the results were inferior because in most cases the autoregression coefficients were not significant. From the results in Tables 2 and 3 we may conclude the following:

1) In all cases the estimated coefficients have the expected a priori signs. The unemployment gap affects negatively price inflation and output growth rates; lagged price inflation and import prices inflation affect positively price inflation; labour productivity affect positively output growth rates.
2) Most estimates are generally acceptable, according to the usual statistical criteria.
3) The specifications of the estimated Phillips and Okun equations are identical between the 15 EU member-states. This ensures comparability of the results.
4) Using computed two quartiles of the estimated coefficients in Table 2, the 15 EU member-states may be categorized into the following groups: a)*Price inflation with respect to cyclical unemployment (quartiles: Q_1=-0.502 and Q_2=-0.342):* more sensitive (P, EL, I, UK, E); average sensitive (A, S, NL, FIN, B); less sensitive (F, IRL, L, D, DK). b)*Price inflation with respect to import prices inflation (quartiles: Q_1=0.165 and Q_2=0.226):* more sensitive (D, P, NL, E, S); average sensitive (F, UK, DK, I, IRL); less sensitive (FIN, A, B, EL, L). c)*Price inflation with respect to lagged price inflation (quartiles: Q_1=0.775 and Q_2=0.835):* less sensitive (L, EL, B, I, FIN); average sensitive (DK, IRL, A, UK, S); more sensitive (F, NL, P, E, D).
5) Using computed two quartiles of the estimated coefficients in Table 3, the 15 EU member-states may be categorized into the following groups: a) *Output growth rate with respect to cyclical unemployment (quartiles: Q_1=-0.936 and Q_2=-0.559):* more sensitive (L, A, P, IRL, FIN); average sensitive (EL, B, S, E, NL); less sensitive (F, DK, I, D, UK). b)*Output growth rate with respect to labour productivity (quartiles: Q_1=0.948 and Q_2=1.052):* more sensitive (EL, UK, NL, P, S); average sensitive (E, D, DK, I, A); less sensitive (L, B, FIN, IRL, F).

Table 2 Estimates of Phillips curves (dependent variable is p)

	α:p_{t-1}	β_0:(U-U_{NR})	γ:pm	$\beta_{t=99}$:$U_{t=98}$	R^2	DW
1. B	0.713 [10.45]	-0.348 [1.78]	0.264 [7.43]	0.947 [14.31]	0.799	2.111
2. DK	0.777 [18.62]	-0.170 [0.87]	0.200 [4.74]	1.000 [23.56]	0.844	1.668
3. D	1.000	-0.268 [1.28]	0.065 [1.80]	0.775 [16.94]	0.725	1.220
4. EL	0.621 [9.01]	-1.018 [3.21]	0.362 [4.14]	1.162 [41.89]	0.841	2.091
5. E	0.933 [11.36]	-0.504 [1.24]	0.142 [3.63]	1.009 [12.17]	0.840	2.143
6. F	0.838 [14.37]	-0.336 [1.54]	0.166 [4.62]	0.943 [10.34]	0.920	1.324
7. IRL	0.779 [12.35]	-0.323 [2.49]	0.218 [4.82]	1.116 [10.28]	0.834	1.688
8. I	0.742 [12.32]	-0.780 [8.48]	0.216 [10.82]	1.062 [49.40]	0.943	2.105
9. L	0.567 [3.15]	-0.295 [0.43]	0.369 [3.14]	1.367 [7.78]	0.849	1.840
10. NL	0.855 [16.68]	-0.435 [2.17]	0.138 [5.24]	1.078 [4.47]	0.760	2.256
11. A	0.808 [9.19]	-0.500 [1.21]	0.254 [2.05]	0.954 [6.90]	0.821	1.984
12. P	0.866 [5.73]	-1.771 [7.07]	0.087 [0.65]	1.039 [36.5]	0.704	1.892
13. FIN	0.772 [9.18]	-0.391 [2.13]	0.233 [3.49]	0.940 [11.43]	0.847	1.390
14. S	0.829 [10.91]	-0.473 [1.78]	0.163 [3.56]	0.878 [27.32]	0.687	2.657
15. UK	0.813 [11.13]	-0.705 [6.43]	0.197 [2.24]	1.003 [22.84]	0.780	2.202
16. EU	0.817 [20.97]	-0.370 [1.09]	0.190 [6.05]	1.014 [48.83]	0.948	1.393

Notes: t-ratios in brackets.

Table 3 Estimates of Okun's law equations (dependent variable is g)

	$\theta_{t=99}$:$g_{t=98}$	δ:(U-U_{NR})	ζ:q	R^2	DW
1. B	0.197 [0.97]	-0.732 [7.41]	1.088 [24.33]	0.999	2.082
2. DK	0.218 [5.86]	-0.500 [4.60]	1.023 [11.94]	0.789	1.508
3. D	0.316 [0.88]	-0.419 [2.64]	0.959 [4.90]	0.933	1.992
4. EL	0.066 [2.23]	-0.893 [5.73]	0.803 [14.30]	0.897	1.785
5. E	0.441 [1.62]	-0.644 [5.48]	0.952 [7.88]	0.961	2.214
6. F	0.276 [1.17]	-0.507 [11.28]	1.198 [19.86]	0.999	2.408
7. IRL	0.145 [29.17]	-0.981 [7.07]	1.170 [11.86]	0.999	2.790
8. I	0.078 [2.54]	-0.494 [5.90]	1.029 [9.12]	0.845	1.069
9. L	0.302 [8.31]	-1.321 [1.64]	1.070 [7.51]	0.893	1.995
10. NL	0.284 [1.77]	-0.611 [17.88]	0.903 [66.73]	0.999	2.135
11. A	0.204 [0.69]	-1.255 [11.30]	1.034 [13.58]	0.999	2.701
12. P	0.058 [1.58]	-1.059 [8.23]	0.919 [9.21]	0.827	1.882
13. FIN	0.221 [1.62]	-0.979 [10.85]	1.125 [14.15]	0.946	1.224
14. S	0.357 [10.24]	-0.728 [7.70]	0.943 [6.86]	0.827	1.556
15. UK	0.274 [6.09]	-0.334 [4.50]	0.835 [8.89]	0.756	1.660
16. EU	0.232 [9.62]	-0.488 [13.73]	0.900 [13.46]	0.880	1.604

Notes: t-ratios in brackets.

4. Estimates of the NAIRU and potential output growth rates

Table 4 presents the estimates for the year 1999 of the NAIRU and the potential output growth rates for the 15 EU member-states, derived from the estimated Phillips and Okun equations presented in Tables 2 and 3, according to equations (10) and (12) respectively. For comparison purposes, in the first two columns of this table the recent OECD (Richardson *et al,* 2000) and Laubach (2001) estimates of the NAIRU are also presented. Furthermore, in the same table the actual rates of unemployment and output growth rates for all the EU member-states are also presented, so the extent and direction of cyclical unemployment and cyclical output may realised for the year 1999, i.e. the final year of the estimation period.

The full path of cyclical unemployment (U_t-U_t^{NAIRU}) and cyclical output growth rates (g_r-g_r^P) for the period 1961-199 and for each of the EU member-states are shown in Figure. In the same figure the correlation coefficients between the variables of (U_t-U_t^{NAIRU}) and g_r-g_r^P) are also reported. Comparing our estimates of the NAIRU with those of the other researchers it is seen in Table 4 that our estimates are higher than the Richardson *et al* (2000) estimates in 10 out of the 14 member-states, i.e. in 71.4 % of the reported cases. However, our estimates are very close to the estimates reported by Laubach (2001), the latter being higher than the Richardson *et al* (2000) estimates in 3 out of the 4 member-states, i.e. in 75.0 % of the reported cases. The precision of our estimates – measured by the reported t-ratios – is much higher than the precision of the Laubach estimates. However, we believe that this is due to the fact that our data were annual in contrast to the Laubach data which were quarterly. Broadly speaking, our estimates are in the range of the generally accepted levels of the NAIRU. From the 1999 values of the actual unemployment rates and actual output growth rates in Table 4, compared to the NAIRU and potential output growth rates, the cyclical unemployment and cyclical output may be computed. It is seen that in 10 member-states (B, DK, EL, E, IRL, I, L, NL, P, FIN) cyclical unemployment is negative, meaning that the NAIRU is greater than the actual unemployment rate, and in 5 member-states (D, F, A, S, UK) cyclical unemployment is positive.

Table 4 Estimates of the NAIRU and potential output growth rate

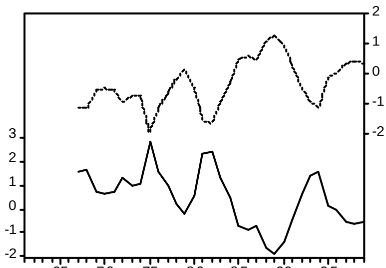
Country	OECD[1]	Laubach[2]	Our[3]N99	U99[5]	Our[4]g99	g99[6]
1. B	8.2		8.8 [14.31]	8.3	1.6 [24.25]	1.9
2. DK	6.3		5.1 [23.56]	4.6	1.3 [13.30]	1.7
3. D	6.9	8.81[.80] 7.33[1.89]	7.3 [16.94]	9.0	2.3 [4.98]	1.7
4. EL	9.5		11.2 [41.89]	9.4	2.4 [14.47]	3.4
5. E	15.1		18.9 [12.17]	17.3	2.3 [8.04]	3.3
6. F	9.5	11.57[1.41] 10.70[3.04]	11.2 [10.34]	11.5	2.4 [19.89]	2.3
7. IRL	7.1		8.7 [10.28]	6.0	6.6 [31.49]	9.3
8. I	10.4	12.45[0.58] 15.58[9.59]	12.9 [49.40]	12.2	1.5 [9.47]	1.6
9. L			3.8 [7.78]	2.7	2.9 [11.20]	3.2
10. NL	4.7		4.3 [4.47]	3.6	1.9 [66.75]	2.3
11. A	4.9		4.2 [6.90]	4.3	2.4 [13.60]	2.3
12. P	3.9		5.1 [36.5]	4.7	2.4 [9.34]	3.2
13. FIN	9.0		10.7 [11.43]	10.1	3.3 [14.24]	3.7
14. S	5.8		7.2 [27.32]	7.8	2.3 [12.32]	2.2
15. UK	7.0	6.10 [1.28] 6.42 [2.47]	6.3 [22.84]	6.5	1.3 [10.78]	1.1
16. EU	8.8		10.1 [48.83]	9.6	1.8 [16.54]	2.1

Notes: t-ratios in brackets. OECD[1] estimates of NAIRU:99. Richardson *et al*, (2000). Laubach(2001)[2] estimates of NAIRU98:4; specifications I and II. Our[3] estimates of NAIRU99. Our[4] estimates of Potential g:99. U99[5] actual U:99. g99[6]: actual g:99.

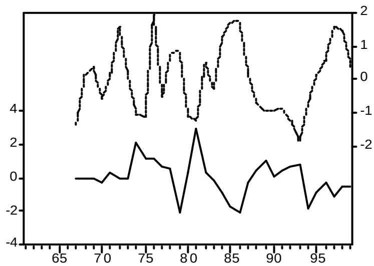
In contrast, it is seen that cyclical output is positive in the same 10 member-states and negative in the same 5 member-states. This means that the inverse relationship between cyclical unemployment and cyclical output holds for at least year 1999.

In terms of the overall path of cyclical unemployment and cyclical output, shown in Figure, our estimates suggest that the extent and direction of changes in these two variables over the period 1961-1999 is mixed across the EU member states. Furthermore, it is seen that the higher the cyclical unemployment is, the lower the cyclical output is. The extent of this inverse relationship between cyclical unemployment and cyclical output can be verified by the negative correlation coefficients reported in Figure 1.

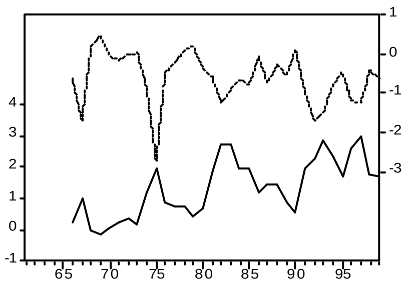
Figure 1. Cyclical unemployment (line) and cyclical output (doted)



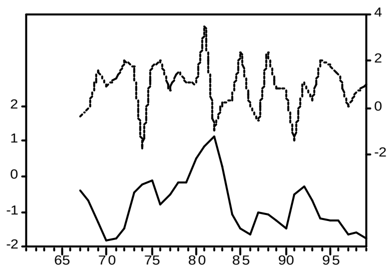
1. Belgium (r=-0.999)



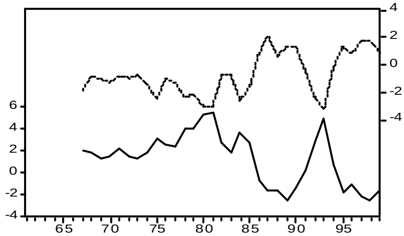
2. Denmark (r=-0.538)



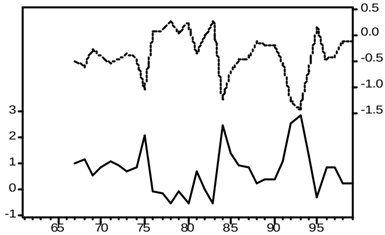
3. Germany (r=-0.701)



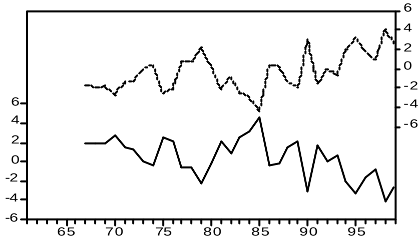
4. Greece (r=-0.115)



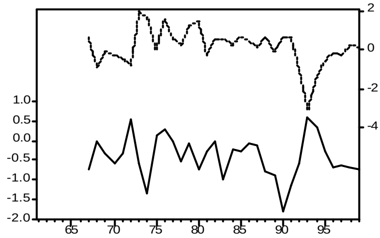
5. Spain (r=-0.965)



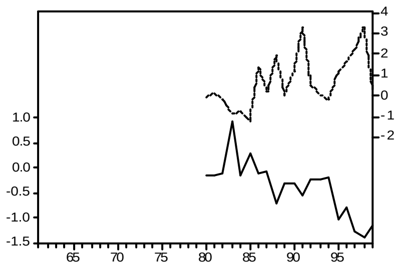
6. France (r=-0.999)

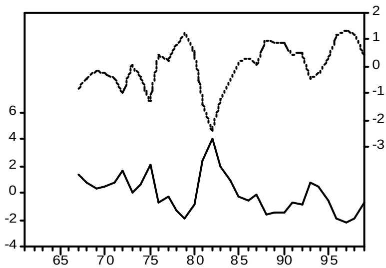


7. Ireland (r=-0.999)

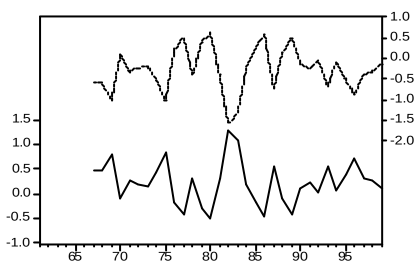


8. Italy (r=-0.451)

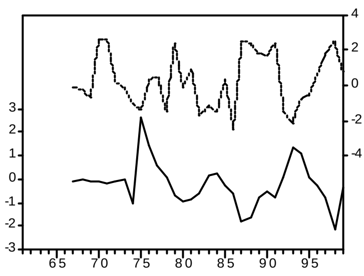




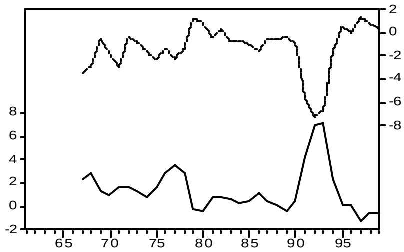
9. Luxembourg (r=-0.724) 10. Netherlands (r=-0.999)



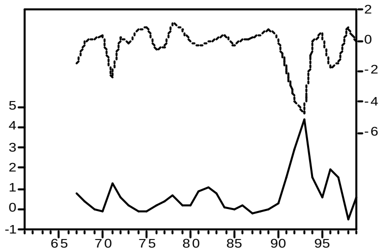
11. Austria (r=-0.999)



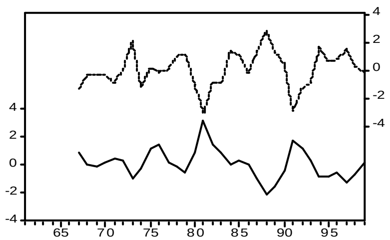
12. Portugal (r=-0.529)



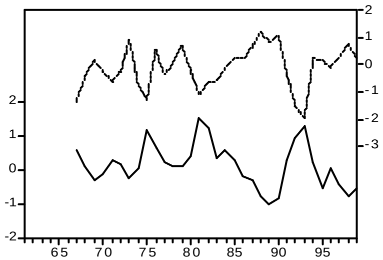
13. Finland (r=-0.919)



14. Sweden (r=-0.885)



15. United Kingdom (r=-0.838)



16. EU (r=-0.803)

It is seen that in most cases (B, E, F, IRL, NL, A, FIN, S, UK) the correlation coefficients are between -1.000 and -0.800, in two cases (D, L) are between -0.800 and -0.600, in three cases (DK, I, P) are between -0.600 and -0.400, and only in one case (EL) is between -0.200 and 0.000. Generally speaking we could say that if we knew the changes in cyclical output we could predict the changes in cyclical unemployment.

5. Concluding remarks

The purpose of this paper was to estimate cyclical unemployment and cyclical output in the 15 European Union member-states. For this purpose a two equations system was estimated for each member state. The first equation was making use of a Phillips type curve, where if the employment rate falls bellow the NAIRU, price inflation will rise until the unemployment rate returns to the NAIRU, at which time price inflation will stabilise at a permanently higher level. However, it was assumed that the NAIRU may, to some extent, be influenced by the path of the actual unemployment rate and furthermore that price inflation was also depending on imported inflation. The second equation was making use of an Okun's law type equation, where deviations of the unemployment rate from the NAIRU produce deviations of the output growth rate from its potential level. Similarly, it was assumed that the potential output growth rate may, to some extent, be influenced by the path of the actual output growth rate and of the labour productivity rate.

Treating both the NAIRU and the potential output growth rate as time varying unobserved stochastic processes, a state-space maximum likelihood estimation method - using Kalman filter where the state variables were random walks - was followed in order to estimate the 15 systems of equations. However, although the Kalman filter estimates are preferred as being economically more meaningful, the variation of the NAIRU needs to be right, too little variation in the NAIRU will result in miss-specified and unreliable equations; too much variation undermines the concept and makes the NAIRU of limited use for policy (Richardson *et al.,* 2000). For this reason we followed the method of the joint estimation of both the Phillips curve and Okun's law equations, although both the NAIRU and the potential output growth rate could be estimated by using only the Okun's law equation. In fact the estimation procedure suggests that the NAIRU and the potential output growth rate are estimated conditionally upon satisfaction of both equations.

The system of the two equations may handle much better the economic policy trade off between inflation and unemployment. This problem is to reduce unemployment by sustained high-growth strategy (suggested by the Okun's law) but at the same time produce a long-run reduction in inflation (suggested by the Phillips curve). The choice to be made is usually between a fast output expansion that rapidly reduces unemployment and a slow output expansion that cuts into inflation, but at the cost of sustained unemployment. Using, for example, the estimates in Tables 2 and 3 in order to make a dynamically simulated EU system of equations, it can be derived that a 1.0% decrease in the unemployment rate in EU in some year is compatible with a 2.1% increase in the output growth rate and with a

1.7% increase in the inflation rate in the same year. Overall, the estimated systems of equations suggest that the extent and direction of changes of cyclical unemployment and cyclical output over the period 1961-1999 is mixed across the 15 EU member states. Furthermore, it is seen that the higher cyclical unemployment, the lower cyclical output. Thus, the application of "common" policies across the 15 EU member states may be questionable because of the different effects of these policies on the various economies.

Finally, it must be noted here that although we tried in this paper to capture some of the problems in the estimation of cyclical unemployment and cyclical output, the usual biases in estimating the NAIRU are the miss-specified Phillips curves and the non-linearities and asymmetries in the effect of the cyclical unemployment on price inflation. Therefore, further research is needed in this field in the light of specific country experiences (Richardson *et al.,* 2000).

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